Effect of Er:YAG laser and EDTAC on the adhesiveness to dentine of different sealers containing calcium hydroxide

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Abstract

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Aim To evaluate the effect of 15% EDTAC solution and Er:YAG laser irradiation on the adhesiveness to dentine of root canal sealers containing calcium hydroxide.

Methodology The crowns of 60 maxillary human molars were ground until dentine was exposed. The teeth were divided into three groups of 20 teeth: group I, the dentine surface received no treatment; group II, 15% EDTAC solution was applied to the dentine; group III, the dentine received Er:YAG laser application (11 mm focal distance with perpendicular incidence to dentine surface; 4 Hz frequency; 200 mJ energy; 2.25 W potency; 62 J total energy; 1 min application time). Aluminium cylinders filled with the sealers, Sealer 26, Apexit, Sealapex and CRCS, were then applied to the treated surfaces. Adhesiveness was measured with a universal testing machine, with traction results given in MegaPascals (MPa). These results were submitted to ANOVA tests.

Results Statistical analysis showed significant differences ($P < 0.01$) amongst adhesiveness values of the sealers and treatments tested. Thus, sealers could be ranked in decreasing adhesiveness values: Sealer 26, CRCS, Apexit, Sealapex. Er:YAG laser irradiation and EDTAC solution application increased adhesiveness values only for Sealer 26 and Apexit. Laser irradiation was superior to EDTAC application only for Sealer 26 adhesiveness values.

Conclusions Er:YAG laser is as efficient as EDTAC solution in increasing adhesiveness of root canal sealers containing calcium hydroxide to human dentine.

Keywords: adhesiveness, endodontics, Er:YAG laser, root canal sealers.

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Introduction

Adhesiveness is a desirable property in a root canal sealer, since gutta-percha by itself does not bind to the root canal walls (Ørstavik *et al.* 1983). Studies have shown that the smear layer acts as a physical barrier, preventing the penetration of root canal sealers into the dentinal tubules (Øksan *et al.* 1993), impairing their adhesion to the root canal walls (Wennberg & Ørstavik 1990) and affecting the efficacy of obturation (Sen *et al.* 1995, Behrend *et al.* 1996). As a result, interest has been generated on how to best remove the smear layer before obturation of the root canal. Some reports suggest the use of organic acids such as citric acid (Baumgartner *et al.* 1984), whilst others recommend the use of chelating agents such as EDTA solution to remove the smear layer (Ciucchi *et al.* 1989). Hill (1959) added 0.1% of the cationic surfactant Cetavlon® (cetyltrimethylammonium bromide, Sigma Chemical Co., St Louis, MO, USA) to EDTA solution, lowering its surface tension and obtaining a bacteriostatic action; this solution is called EDTAC.

Recently, the advent of laser irradiation to promote root canal cleaning has been promising (Kimura *et al.* 2000). It has been demonstrated that the Er:YAG laser can remove smear layer from root canal walls and possibly more effectively than EDTA and citric acid (Takeda *et al.* 1999). Others (Pecora *et al.* 2001) verified that the

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adhesiveness of epoxy-based root canal sealers increased after irradiation of dentine with Er:YAG laser. However, the same was not observed with zinc oxide–eugenol-based sealers, which did not adhere more effectively on dentine following irradiation with Er:YAG laser (Sousa-Neto *et al.* 2002). The influence of laser irradiation on the adhesion of sealers containing calcium hydroxide on dentine has not been evaluated. Thus, the objective of this study was to evaluate *in vitro* the adhesiveness of root canal sealers containing calcium hydroxide on human dentine treated with 15% EDTAC solution application or Er:YAG laser irradiation.

Materials and methods

Sixty human molars, extracted for periodontal reasons and stored in 0.1% thymol solution under refrigeration, were used. Twenty-four hours before use, the teeth were washed with running water to eliminate traces of thymol. The enamel of the occlusal surface of these teeth was removed with a number 4138 diamond bur (KG Sorensen, Barueri, SP, Brazil) in a high-speed handpiece with water coolant. Samples were smoothed on fine sandpaper on a flat surface to remove small irregularities. After obtaining a flat occlusal surface, teeth were fixed by their roots in an acrylic resin base (shaped as a 30-mm side cube) to be adapted to the universal testing machine (MEM 2000, Curitiba, PR, Brazil).

Samples were randomly divided into three groups of 20 teeth each, receiving different treatments. The dentine surface of samples in group I received no treatment; group II was treated with 50 μL of 15% EDTAC solution (EDTA + 0.1% Cetavlon®) for 5 min on the dentinal occlusal surface; group III samples had their dentinal surfaces irradiated with Er:YAG laser (KaVo KEY Laser II, Werthausen, Germany) by means of a number 2051 handpiece with the following parameters: 11 mm focal distance with perpendicular incidence to dentine surface; 4 Hz frequency; 200 mJ energy; 2.25 W potency; 62 J total energy; 313 mean impulse and 1 min application time. Water cooling, provided by the laser handpiece, was constant during irradiation.

Four endodontic root canal cements were studied: Sealer 26 (Dentsply, Petrópolis, RJ, Brazil), Apexit (Vivadent, Schaan, Liechtenstein), Sealapex (Kerr, Romulus, Michigan, USA) and calciobiotic root canal sealer (CRCS) (Hygenic, Mahwah, NJ, USA). Each experimental group received one of the sealers. Aluminium cylinders (10 mm high × 6 mm i.d.) with stainless steel handles were placed on the dentine surface and fixed to the teeth with small amounts of wax on their lateral side. After manipulation according to the manufacturer's instructions, the cements were placed carefully inside the cylinders with the aid of a vibrator (Buffalo Dental Manufacturing Co., Syosset, NY, USA) for 1 min to avoid air bubbles. The material was then placed in a 37 °C, 95% humidity environment for a period three times greater than the normal setting time of the cement (Sealer 26 = 42 h; Apexit = 6 h 50 min; Sealapex = 51 h 5 min; CRCS = 32 min). The samples were placed in a universal testing machine (MEM 2000, EMIC, PR, Brazil) in order to create a vertical force. An oscillating joint placed between the holder and the measuring cell prevented other forces that could cause experimental errors. The machine was calibrated to run at a constant speed of 1 mm min^{-1} until the detachment of the aluminium device containing the cement. The traction force necessary to detach the device from the tooth in MegaPascals (MPa) was recorded.

Statistical analysis was performed using ANOVA complemented by Tukey's test ($\alpha = 0.01$).

Results

Figure 1 shows the results obtained for the adhesiveness test for the four sealers studied. Statistical analysis revealed significant differences ($P < 0.01$) between sealers, which allowed their ranking in decreasing adhesiveness values: Sealer 26, CRCS, Apexit, Sealapex.

Statistical analysis also showed significant differences ($P < 0.01$) between treatments. Er:YAG laser irradiation promoted the highest adhesiveness values, whilst untreated dentine surfaces had the lowest values.

Er:YAG laser and EDTAC solution were able to increase significantly the capability of Sealer 26 and Apexit root canal cements to adhere. These treatments, however, did not increase adhesion of Sealapex and CRCS sealers to dentine. Er:YAG laser was significantly superior to EDTAC in promoting higher adhesion values for Sealer 26 cement only.

Discussion

Er:YAG laser, when applied on dentine, promotes its ablation (Keller & Hibst 1989), vaporizing the smear layer and exposing dentinal tubules (Takeda *et al.* 1999). It also modifies the dentinal surface morphologically, creating a micromechanical retention pattern (Tanji *et al.* 1997). EDTAC application removes smear layer due to its chelating action (Goldberg & Abramovich 1977).

Smear layer removal promotes penetration of the endodontic cement into the exposed dentinal tubules,

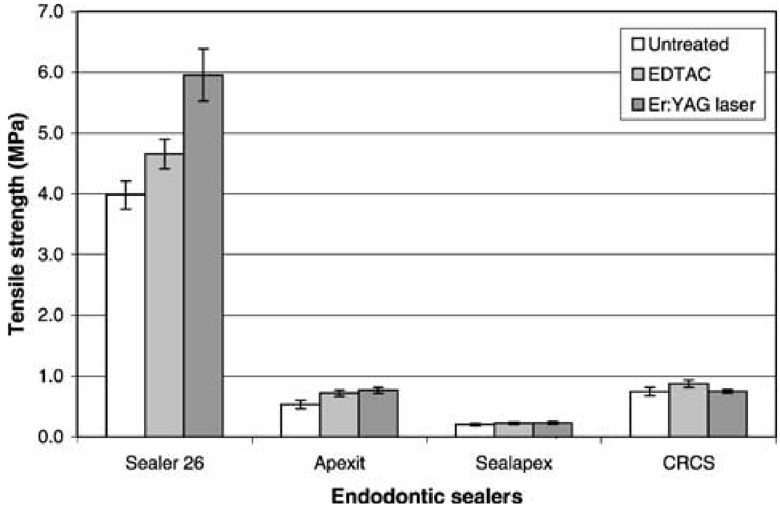

Figure 1 Mean tensile strength versus endodontic sealers tested.

which increases the contact surface between the sealer and dentine and allows a mechanical bond between them (Pecora *et al.* 2001). The untreated dentine, covered by smear layer, reduces sealer adhesiveness, since it acts as an interface between the cement and dentine (Øksan *et al.* 1993). This explains the increase of adhesiveness values promoted by Er:YAG laser irradiation and EDTAC application for some sealers.

The American Dental Association, in 1983, established a series of regulations and tests for the study of the physical properties of root canal sealers. However, due to the lack of consensus amongst researchers, adhesion tests were not standardized. Ørstavik *et al.* (1983) proposed the use of the universal testing machine to test root canal sealer adhesion. This method was also used by Hyde (1986), Wennberg & Ørstavik (1990) and Sousa-Neto *et al.* (2002). The universal testing machine promotes better uniformity and greater reproducibility, providing more accurate results and tension values in MPa that favour comparison of results.

All the endodontic cements used for this experiment contain calcium hydroxide, but there were differences between them that were reflected in their behaviour. Sealapex had the lowest adhesiveness values with the different treatments applied to dentine. This can be explained by its long setting time (Hyde 1986), high solubility and disintegration values (Hyde 1986, Fidel *et al.* 1994), low cohesion (Fidel *et al.* 1994) and low flow rate (Birman *et al.* 1990).

CRCS is a zinc oxide–eugenol-based sealer, similar to the Grossman cement, but with calcium hydroxide added. Adhesiveness of such sealers is based on the electrostatic bonds with dentine (Sousa-Neto 1997). Since it does not depend on a mechanical bonding, dentine surface treatment with Er:YAG laser or EDTAC did not promote a significant increase in adhesion capability of this sealer.

Dentinal surface treatment with Er:YAG laser or EDTAC resulted in an increase in adhesion of the Apexit sealer when compared to the untreated group. This can be explained by the increase of contact area between cement and dentine, promoted by smear layer removal (Fidel *et al.* 1994).

Amongst all sealers tested in this study, the epoxy-based cement Sealer 26 showed the highest adhesiveness values in different dentinal surface treatment conditions, which can be explained by its cohesive structure. Other reports reinforce the high adhesive capacity of epoxy-based root canal sealers (Wennberg & Ørstavik 1990, Gettleman *et al.* 1991, Fidel *et al.* 1994). In this study, dentinal surface treatment with EDTAC solution or Er:YAG laser promoted an increase in adhesiveness of Sealer 26 cement on dentine, compared to the untreated group. Er:YAG laser irradiation promoted superior adhesion values when compared with EDTAC for Sealer 26 but not for other sealers.

Conclusions

1 Dentinal surface treatment with EDTAC solution or Er:YAG laser promoted an increase of adhesiveness of Sealer 26 cement on dentine, compared to the untreated group.

2 Er:YAG laser was more efficient than 15% EDTAC solution in increasing adhesiveness of Sealer 26 root canal cement on human dentine.

3 Er:YAG laser was as efficient as 15% EDTAC solution in increasing adhesiveness of CRCS, Apexit and Sealapex root canal sealers on human dentine.

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